Force Curves to Demonstrate Methods to Increase Musculoskeletal Loading with the ARED

Completed Technology Project (2013 - 2013)

Project Introduction

Current resistance exercises on ISS do not meet the requirements set by expert panels in that the eccentric loads are less than concentric loads, forces are variable with velocity, and lack of back support limits the amount of load that can be applied to the hip. The proposed activity will demonstrate through ground reaction force comparison of current exercise to modified exercise on the ARED that the desired forces can be safely generated with modifications. The force curves may support future ISS studies that will demonstrate more efficient exercises for bone and muscle that can be performed on less complex and more durable exercise hardware. Safe and effective exercises demonstrated on ISS will support improvement of exercise guidelines issued by the Office of the Surgeon General, the National Institute of Health, and the Center for Disease Control.

a) Addition of flywheels to space flight exercise hardware in order to simulate free weight inertia increases wear on equipment and has resulted in costly repairs to exercise hardware in space. Ground based exercise studies have shown improved bone density and muscle strength with exercise equipment that use pneumatic resistance forces and have no added inertial forces beyond that derived from the mass of the human body. An exhaustive literature search revealed no direct comparisons between pneumatic resistance exercise devices and weight stack or free weight exercises used to maintain or strengthen bone and muscle. In the absence of a direct comparison, exercise prescriptions and exercise equipment requirements specifying simulation of weight stack type rate dependent variability in forces on the ARED for health maintenance have been based upon opinion. Use of weight stack exercise equipment and flywheels to simulate weight stack characteristics reduces loads below the target level in up to half of the weight lifting cycle, results in poorly controlled rate dependent variability in loads, and can induce injurious peak loads. This variability undermines the exercise requirements for constant load with a high eccentric to concentric load ratio agreed upon by musculoskeletal and exercise scientists who defined ARED requirements for ISS. Numerous studies in the literature show exercise equipment that provides high concentric and eccentric loads improves bone density and muscle strength, with and without transient loads due to mass moment of inertia. Despite low levels of evidence that impact (separate from high sustained loads) is beneficial to bone and muscle, many exercise guidelines continue to state impact is desirable for bone maintenance. Impact is contraindicated in individuals with arthritis and joint injuries. Therefore, use of the ISS ARED to demonstrate that high constant loads without transient loads maintains bone and muscle will be beneficial to NASA in simplifying hardware design and maintenance and will improve exercise safety. Information generated in this proposed activity will be used to support exercise improvements that will enhance durability, safety, and efficiency of exercise hardware for space flight.

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Center Innovation Fund: JSC CIF

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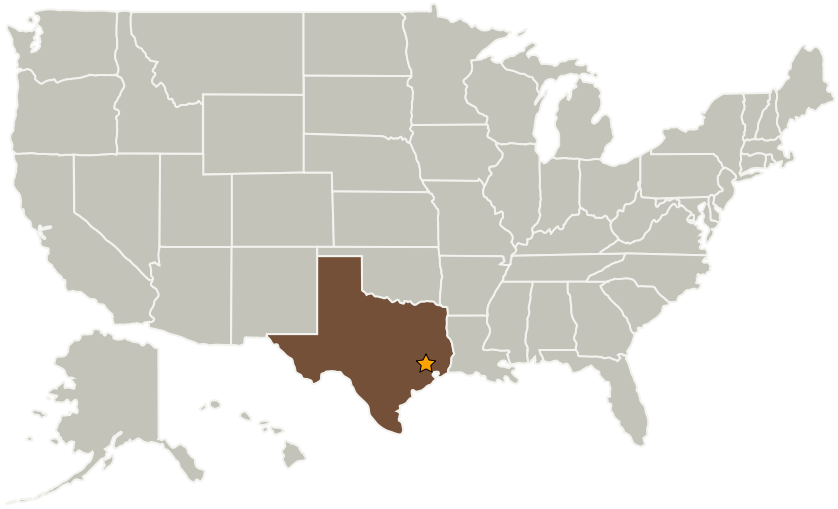
Anticipated Benefits

a) Information generated may be used to develop a space flight study designed to provide evidence to enhance safety and efficacy of exercise prescriptions used to prevent and reverse osteoporotic changes and muscle loss associated with aging on earth. Despite the numerous studies in the literature showing exercise equipment that provides high constant concentric and eccentric loads increases muscle strength and bone mass, many exercise guidelines continue to state impact is desirable for bone maintenance. Impact is contraindicated in individuals with arthritis and joint injuries. Osteoporotic individuals are cautioned to avoid weight lifting exercises in which variations in posture can cause skeletal overload. Use of the ISS ARED with the flywheel disengaged to demonstrate that high constant loads (without impact or variable peaks) maintains bone will provide the needed public demonstration of safe and effective exercises for the aging population. Correcting misperceptions about the musculoskeletal system's need for impact and high transient loads will enable physicians and exercise scientists and specialists to develop safe and effective exercise guidelines for the aging population. The first step in this activity is to provide objective evidence (force curves) that disengagement of the flywheel on the ARED, use of back support for hip exercises, and a modified lifting technique in which both legs are used for the concentric contraction and single leg is used for the eccentric contraction provides high sustained forces with an optimal eccentric force of 100% to 110% of the eccentric force.

Primary U.S. Work Locations and Key Partners



Project Management

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Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.2 Prevention and Countermeasures

Center Innovation Fund: JSC CIF

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Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations
Texas